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THE USE OF ISOTOPES AS INDICATORS IN BIOLOGICAL RESEARCH[1]

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WHILE it is undoubtedly true that the chief tool and weapon in research is thought and ideas and that a large amount of experimental work in biology is more or less wasted for lack of thought, it is not less true that progress depends to a very large extent upon methods and that new methods may open up new and fruitful fields.

It is my task to-day to present some thoughts about a new and, as I believe, extremely powerful tool for biological and biochemical research: A small number of isotopes which can be readily distinguished and quantitatively determined by relatively simple physical means.

Isotopes are atomic species which differ in weight, but have the same nuclear charge and as a consequence of this last-named property they are practically identical chemically and will behave in the same way in organisms. Isotopes of lead are available in nature which can be recognized and quantitatively determined physically by their radioactivity, and recent progress is making available radioactive isotopes of a number of elements, including some of those which are of special importance in living organisms.

The methods for recognizing and estimating radioactive substances are highly developed and easy of application.

Hevesy, himself a pioneer in the chemical and physical study of isotopes, was the first to see the possibilities offered in biology by recognizable isotopes and made the classical and fundamental experiments with radioactive lead in 1921.

Attempts over several years to separate radium D from lead by chemical means had thoroughly convinced him of their identity, but the atoms of the one carried a label, so to speak, in their radioactivity. When a plant is grown in a solution containing lead, this ele-

[1] Address given at the Harvard Tercentenary Conference of Arts and Sciences, September 10.

ment will enter the roots and become distributed all through the plant, where it can be detected chemically and determined quantitatively in the ash of stems, leaves, fruits and so on. If after a certain time the plant is transferred to an ordinary nutritive solution, containing no lead, the quantity once taken up is retained and one would assume it to be firmly combined. If a radioactive variety of lead is used the detection and estimation becomes greatly simplified, but the really important point is brought out when a plant is grown first in a solution containing radioactive lead, until equilibrium is reached, and then transferred to a solution with the same concentration of ordinary lead and it is found that the radioactive atoms gradually leave the plant and are regularly exchanged with the ordinary variety, that in other words lead atoms are in reality never fixed anywhere, but are always on the move up and down the plant to and from the single cells, to and from the organic lead compounds which are continually formed and reformed. This concept of the lability of compounds and mobility of atoms within the living organism is fundamental, and it has been broadened and deepened by all subsequent research. It turns out in this particular case that lead atoms in organic combination within a plant can also be exchanged to some extent with other heavy metals, especially copper.

Lead is a decidedly foreign substance within an organism, and it might be thought that elements which were normal constituents of the tissues would settle down more permanently. Preparing a radioactive phosphorus isotope from ordinary sulfur Hevesy and his associates have utilized this substance for a number of experiments both on plants and animals which are still in progress. Professor Hevesy has kindly allowed me to mention some of his results. On plants the results correspond closely to those obtained with lead; phosphorus atoms will travel constantly throughout the plant and be transferred during growth from old leaves to new and *vice versa,* showing much more extensive transports of substances from leaves to roots as well as from roots to leaves than hitherto assumed.

On animals it is found, and was perhaps to be expected, that phosphorus introduced by injection is almost at once distributed with the blood all over the body and becomes excreted through the kidneys and also to some extent through the gut. In one experiment on a human subject 20.3 per cent. of the radioactive phosphorus introduced was eliminated in 4 days through the kidneys and 2.5 per cent. through the gut. When in another experiment the phosphorus was taken by mouth 15.5 per cent. was eliminated through the gut and 17.9 per cent. through the kidneys, showing that quite an appreciable amount had not become absorbed.

Most of the radioactive phosphorus introduced in a mammal leaves the blood within a short time, exchanging with the phosphorus of the tissues. The exchange with the inorganic phosphorus is almost instantaneous, but also the organic phosphorus present in muscles and other organs comes gradually into an exchange equilibrium with the radioactive element.

To my mind the most interesting result is the extensive exchange taking place in bones and teeth. It is, of course, well known that the organism is able to draw upon the skeletal system as a reserve of inorganic salts, but even remembering this I have never before been able to look upon the atoms deposited in practically insoluble salts and at a considerable distance from any blood vessels, in the dentine for instance, as being in constant interchange with the atoms of the salts in solution in tissue fluids and blood. This is, however, what the experiments clearly indicate. When a single dose of radioactive phosphorus is given to an adult rat and the animal is killed after one week 2 per cent. of the dose is found in the bones, 0.2 per cent. in the molars, 3.3 per cent. in the incisors (which are growing all the time) and 3.2 per cent. in the liver. When the rat is allowed to live on for one or two weeks more the content of radioactive phosphorus (corrected of course for the regular decrease in activity) gradually decreases, because replaced by the ordinary phosphorus of the diet. This decrease is conspicuous in the bones and in the liver, but has not so far been observed in the teeth, where the exchange is much slower. When the long incisors are cut in pieces and the growing roots, a middle portion and the tips, which one would expect to be quite outside any circulation, are examined separately it is found that even here the radioactive phosphorus penetrates and an exchange takes place. So far it has not been possible to examine the enamel separately and it is a matter for conjecture whether or not this, the hardest of all tissues, is taking part in the processes of exchange.

In young rats the exchange takes place more quickly, as one would expect, and relatively more is taken up by the growing bones and teeth, but on the whole the same relations are observed.

The heavy hydrogen isotope, called deuterium to distinguish it conveniently from the ordinary hydrogen or protium, is as an isotope in a class by itself. On account of the 100 per cent. difference in atomic weight and the fact that D and H may be present and act as naked nuclei, its chemical behavior is not exactly the same as that of protium. Several reactions carried out with deuterium are definitely slower than the corresponding ones with protium. The rate of hydrogenation of fats with deuterium gas, for instance, is only about half the rate for protium. The equilibrium

nstant of numerous reactions in which deuterium rticipates is markedly different from that obtained th protium.

Several vital processes are slowed down by heavy ater, deuterium oxide, and in high concentration it harmful or even lethal to many organisms. With is aspect of the problem I do not propose to deal. he observations go to show that in concentrations low 10 per cent., where the deuterium is mainly resent as DHO, heavy water behaves in the organism st as ordinary water and can safely be used as an dicator. Deuterium can be estimated with great ecuracy as "heavy water" in mixtures with ordinary ater by specific gravity determinations, and the chief ifficulty is to purify the sample so that it contains nly water. For the specific gravity determination self fairly simple methods are available which are ccurate to the 6′ decimal place, corresponding to 001 per cent. heavy water in samples containing rom 0 to 5 per cent. over and above the 0.05 per cent. resent in all natural waters. The falling drop method f Barbour can attain this accuracy on small fractions f 1 ml.

Heavy water can be utilized in the study of a variety f biological problems. It was shown by Hevesy and Hofer that D_2O either taken by mouth or, in aquatic nimals, diffusing in through the integuments and gills, s rapidly and evenly distributed all over the body so hat the concentration in the urine measures exactly he concentration in all the water in the body. We ave attempted in collaboration with Hevesy to use $_2O$ to measure permeability, and important infor- ation can be gained, but there is a definite limitation o its use. It can show whether a membrane is ermeable to water or not. In the eggs of certain shes, notably the trout, there is a stage in which the itelline membrane is stated to be impermeable to ater. We have confirmed and extended this state- ent by means of D_2O. Immediately after laying, rout eggs swell by taking up water. Heavy water ill penetrate at a rapidly decreasing rate, and after couple of hours the penetration ceases. When at his state trout eggs are transferred to a heavy water olution not a trace of D_2O is found, even after a day r more, in the water to be distilled off from the eggs fter they have been washed superficially with ordi- ary water. At a much later time, when the develop- ent of the embryo has reached the stage with just isible eyes, the membrane again becomes permeable o that water can pass in osmotically and, as no swell- ng is observed, excretion of water must be taking lace. In all cases where it is desirable to find out ualitatively whether or not water can penetrate a embrane the heavy water can be used as an indicator f very high sensitivity.

In experiments on frogs we have been able to solve the much debated problem whether or not there is a selective permeability for water in one direction. When the legs of a frog are immersed in a known volume of, say 3 per cent. D_2O, the rate at which D_2O diffuses in can be ascertained and compared with the rate at which it diffuses out, observed when a frog is saturated with 3 per cent. D_2O and the legs immersed in H_2O. All the experiments made go to show that there is no significant difference in the diffusion rates out- side → in or inside → out.

The diffusion rates measured with heavy water on living membranes are of a very low order compared, for instance, with collodion membranes, but unfor- tunately the heavy water can not be used to measure the rate at which water passes through a membrane by osmotic pressure differences. It is tempting to assume that a certain concentration gradient, say of one mole per liter of D_2O, can cause the same move- ment of D_2O molecules across a given membrane as the water movement brought about by a pressure dif- ference of one mole of a substance which can not pass the membrane, but Jacobs has pointed out that the conditions are not comparable and it is certain that in the cases examined by us, mainly on frog's skin and on artificial membranes, the rates are very different and the osmotic water transport for a given pressure difference generally larger, while the proportion varies from one membrane to another.

A very large and, as I believe, very fruitful field of research is opened up by the observation that an exchange will take place between the deuterium atoms of heavy water and certain protium atoms of organic substances.

If a definite amount of an organic substance, a pro- tein say, is dissolved in a suitable amount of water with a known content of D_2O and the water thereupon distilled off the D_2O content is found to be reduced, and when the dry residue is burned and the water formed by combustion from the hydrogen in the pro- tein molecule is also tested the missing D_2O is found there.

At least with dilute solutions there is a definite rela- tion between the D_2O percentage of the combustion water and the D_2O content of the water with which the protein was in equilibrium. For albumin we have found that the D_2O content of the combustion water is 40 per cent. of the distillate, and we take this to mean that 40 per cent. of the hydrogen atoms in the protein are in a labile state which allows them to con- tinually change places with the hydrogen atoms of the surrounding water.

The experiments of Bonhoeffer and others have shown that hydrogen atoms directly attached to the carbon chain or ring are generally not liable to ex-

change, while the hydrogen of organic acids, hydroxyl, amino and aldehyde groups are readily exchangeable. In certain cases conditions are more complicated, as in the enol form of acetone or in maleic acid, where one or two hydrogen atoms are readily exchangeable to the outside, while a slow exchange can take place within the molecule between this and all other hydrogen atoms. In suitable conditions all the hydrogen atoms can therefore be exchanged with deuterium.

In a recent paper by Münzberg this slow exchange was specially studied on pyrogallic acid with the result that the exchange in 3 hydroxyl groups was practically instantaneous. One of the D atoms thus introduced could change places with one of the fixed H atoms by a keto rearrangement taking place at intervals, and this again could change places further by a spontaneous change in the place of the double bond, occurring at very long intervals. The final result was that all the 6 hydrogen atoms could be exchanged, but at ordinary temperatures this would take years.

It is possible to utilize compounds in which deuterium atoms have been built into stable positions and also the exchange processes themselves for the solution of important biochemical problems.

Schoenheimer and Rittenberg are working along the first of these lines. By the well-known process of hydrogenation they have built deuterium atoms into linoleic acid and fed the deuterium containing fat to mice. They expected to find that small amounts of fat given to animals on an insufficient diet would be readily oxidized, but they did find that even in these circumstances most of the fat was deposited before being utilized. When the fat is broken down in the body the deuterium is set free as heavy water which will become uniformly distributed in the body. In rats and mice in which the D_2O concentration was kept approximately constant over a period of a week or 10 days we (Ussing and Krogh) found small amounts of D in the body fats, indicating a new formation of fat from carbohydrate, a formation which it should be possible to measure quantitatively when the relative proportion of deuterium in carbohydrate and in fat formed from it can be determined. Schoenheimer and Rittenberg have also recently solved the long-debated problem of desaturation of fatty acids as a normal process in the living organism by showing that when saturated fatty acids containing deuterium were fed to mice, and the body fats extracted after a suitable period and fractionated so as to separate saturated and desaturated acids, an appreciable proportion of the deuterium was found in the desaturated fraction.

Schoenheimer and Rittenberg have pointed out the great possibilities for studying intermediary metabolism opened by introducing into the body substances suspected of being links in the chain of conversion and having these "labeled" with deuterium in a stable position. When this D is afterwards found in the normal end product of the series at least the possibility of the conversion in the body is proved. They have applied the procedure in the cholesterol-coprosterol series with very promising results, and I am convinced that they have hit upon a principle of very general applicability. I expect that in a not too distant future a series of organic substances containing D atoms in suitable stable positions will become available commercially.

In my laboratory Ussing and myself, in regular consultation with Hevesy, have made a number of preliminary experiments along the second line indicated. We exposed organisms to definite concentrations of D_2O to study the exchange between the water and the tissue substances. We hoped to be able to distinguish between a more or less permanent uptake of deuterium by new formation of tissue elements and a simple exchange, of the same type as that observed *in vitro*, but possibly different in amount, owing to essential differences in constitution between proteins as isolated and proteins built into living systems.

Our first experiment was done on four equal lots of peas which were soaked in water containing D_2O and then allowed to sprout in the dark for different lengths of time up to 10 days. Contrary to our expectation the maximum of deuterium in the dry substance was found just after soaking when deuterium was present in the dry substance corresponding to an exchange percentage of 26. Later on about 20 per cent. were found so that, apparently at least, no building in of deuterium into stable positions took place.

Frogs were saturated with about 1.2 per cent. D_2O, which is accomplished simply by keeping a small amount of water with an appropriate percentage circulating about them for several days. One frog was killed and analyzed while exposed in this way, and another transferred to a small volume of ordinary water, bringing the concentration down to approximately 0.4 per cent. In both cases the percentage saturation of the combustion water corresponded to 30 per cent., showing, apparently, that we have to do at least in the main, with a simple reversible exchange.

In a series of experiments on rats and mice kept in a cage in a sealed metabolism chamber and maintained for varying lengths of time at an approximately constant concentration of D_2O in their body fluids the deuterium concentrations in single dry organs were measured and compared with the concentrations in the distillates from them, which were always identical for the whole body. In most organs a regular exchange took place, so that an approximate equilibrium in the neighborhood of 50 per cent. was reached within a few days, but the muscles behaved differently. In the

first experiments, which lasted a week or more, the deuterium concentration reached very high figures of about 70 per cent., but the increase was very slow, as shown in a one-day experiment on a rat in which the muscles had reached only 19 per cent. when the liver was 47. An experiment on three mice is especially instructive. These mice were brought by injection to about the same concentration of D_2O and kept together in the same metabolism chamber. One was killed after 1 day and showed in the proteins of muscle and bone an exchange of 11 per cent., while in the internal organs it had reached 20 per cent. The second mouse was killed after four days when the percentage saturation in the muscle and bones was 25 per cent. and in the internal organs 37 per cent. The remaining mouse was now given ordinary water to drink, which in 5 days reduced the concentration of D_2O in the body fluids from about 2 to about 1 per cent. The deuterium content in the proteins of the internal organs went down very nearly in the same proportion, showing now a 40 per cent. concentration, but in the muscle (and bone) the absolute content of D went up further, raising the proportion to 76 per cent.

It seems out of the question that a breakdown and reconstruction of muscular tissue should proceed at anything like this rate, and we are reminded of the slow exchange taking place within molecules referred to above. An exchange of this type might in the living organism be correlated with the activity, and to test this suspicion the following experiments were made on frogs with a suitable concentration of D_2O, in which one leg was denervated, while the other was stimulated to twitches at two to three seconds interval over 24 hours. We found an exchange of about 9 per cent. in the leg kept quiet and 12 per cent. in the leg which had performed about 36,000 twitches with an aggregate duration of less than 30 minutes.

It can not be sufficiently emphasized that the experiments so far made are preliminary and tentative. At the same time it seems to me that the general lability of substances and tissues in the organism already revealed is of very great significance and that we may look forward to important developments.

With regard to the utilization of heavy water as an indicator we are strongly in need of a comprehensive study of the exchange in protein substances *in vitro* both static and dynamic, studying the influence of conditions like pH, temperature, salts and so on on the final equilibrium and the rate at which it is approached.

There are, I believe, great possibilities for the further use of the hydrogen isotope in biology, but it must be admitted that the somewhat cumbersome technique of purification and determination of the deuterium oxide is in the way of rapid progress along this line.

From this great country with its enormous resources we may perhaps even look forward to the separation of other biologically important isotopes which can be determined by specific gravity methods. Still I think that the radioactive isotopes are likely to become of paramount importance because the determination is comparatively easy and the activity remains unaffected by any chemical treatment, including ashing.

The radioactive isotopes to be used in biology must possess a fairly strong activity which generally means a short radioactive life. On the other hand, the life, as characterized by the time of reduction of the activity to one half, can easily become too short for biological or even chemical purposes.

A large number of isotopes have been prepared with half times between a fraction of a second to a few hours. These will not as a rule be available for biological research.

The half time of radioactive lead (thorium B) is 11 hours and of phosphorus 16 days, which is very convenient for our purposes. A radioactive sulfur can be generated having a half time of 60 days and reports are presented of carbon with a somewhat similar length of life.

I am exceptionally fortunate in having become associated with Professor Hevesy and through him also with Bohr. The study of radioactive isotopes is to be pushed forward in Copenhagen, and a powerful plant is being erected for their generation. We are determined to do the best we can, but we cordially invite both competition, cooperation and criticism.

SCIENTIFIC EVENTS

LETTERS AND MANUSCRIPTS OF T. H. HUXLEY

IN a letter to the London *Times* dated December 31, 1936, Lord Rayleigh, chairman of the Governing Body of the Imperial College of Science and Technology, London, and Sir Frederic G. Kenyon, chairman of the Friends of the National Libraries, have made an appeal for subscriptions to a fund to make possible the preservation of a unique collection of Huxley's letters and manuscripts, now in the possession of Mrs. Leonard Huxley. The letter follows:

"In your issue of February 14, 1936, you published an article by Sir Frank Heath describing the very interesting and historically valuable collection of letters and manuscripts relating to T. H. Huxley which are now in the possession of Mrs. Leonard Huxley.

There has been a general desire to preserve this unique collection as a whole and to house it at the Imperial College, where it could be studied by serious students and seen under suitable conditions by interested members of the public.

"In February last the governing body of the college issued an appeal to old students and friends of the college in the hopes of raising £2,000, the sum asked for the letters, and an additional £500 which is the estimated cost of binding and housing the collection. Before issuing this appeal they consulted the authorities of the British Museum and the Friends of the National Libraries, who are favorable to the scheme. The Friends of the National Libraries issued a supporting appeal to members of their association at the same time. Altogether a sum of £1,200 has so far been collected or promised. Of this, £464 has been received through the efforts of the Friends of the National Libraries, £150 has been granted by the Pilgrim Trust, £200 from one old student of the college, and £50 from Sir Robert Hadfield.

"The governing body and the council of the Friends of the National Libraries are most anxious to secure the additional money necessary soon. Otherwise it is probable that the collection will be broken up and lost to the country. It is possible that some readers of your paper have not yet heard of the appeal and would be willing to help to preserve the collection, which includes among other items of great interest almost the whole of Darwin's correspondence with Huxley, over 400 letters to and from Hooker, in addition to many hundreds of letters from Tyndall, Lyell, Herbert Spencer, Haeckel, Agassiz and many other men of great prominence in Huxley's time. It also includes many of Huxley's original manuscripts and notebooks.

"Contributions should be sent to the Secretary of the Imperial College, Prince Consort Road, South Kensington, S.W.7, or to the Secretary of the Friends of the National Libraries, care of British Museum, W.C.1."

RESEARCH ON METALS

THE rewards of cooperation in research in the field of metals through joint investigation of fundamental problems by physicists, metallurgists and chemists were discussed by leaders in these fields at a meeting held at the Massachusetts Institute of Technology on January 28 and 29 under the auspices of the institute and the American Institute of Physics.

The meeting emphasized the promising trend toward a most productive type of research in which technical workers bring to problems of fundamental interest the specialized knowledge and methods of their several fields. The very important results of joint research are nowhere more evident than at the institute itself, where many investigations are brought to successful conclusions through interdepartmental cooperation.

The purpose of the meeting was to discuss thoroughly recent developments in the physics and chemistry of metals, as well as the opportunities for still greater advances through the combined cooperative effort of all workers whose knowledge may in some way contribute to problems of mutual interest. From a half to one hour each was allowed for the presentation of important papers and ample time was given for discussion, thus permitting an interplay of viewpoints not possible in the usual scientific meeting.

Some of the more general papers presented were: "Research Problems in the Steel Industry," by Dr. E. C. Bain, United States Steel Corporation; "Inclusions in Ferrous Alloys," by Dr. A. B. Kinzel, Union Carbide and Carbon Company; "Flow Phenomena in Heavily Stressed Metals," by Professor P. W. Bridgman, of Harvard University; "Electronic Structures in Metals and Alloys," by Professor J. C. Slater, head of the department of physics of the Massachusetts Institute of Technology; "Corrosion," by Dr. J. R. Burns, of the Bell Laboratories; "Elastic Properties of Ferrous Alloys," by Professor A. V. de Forest, of the Massachusetts Institute of Technology, and "Chromium-Nickel-Iron Alloys," discussed by Dr. V. N. Krivobok, of the Allegheny Steel Company.

In another group of papers various techniques and their applicability were presented, while in the third group some especially complex scientific problems met with in ferrous alloys were discussed.

Arrangements for the meeting were in charge of Professor John Wulff, of the institute, who acted as secretary, and Dr. Harry A. Barton, director of the American Institute of Physics.

THE NORTHWEST SCIENTIFIC ASSOCIATION

THE thirteenth annual meeting of the Northwest Scientific Association was held on December 29 and 30, 1936, at the Davenport Hotel in Spokane, Washington.

President George F. Simmons, of the Montana State University, lectured at the general meetings on "The Mechanisms of Reproductive Periodicity in Mammals" and "A Windjammer Voyage to Treasure Island." Seven section meetings were held as follows: Bacteriology-Public Health, Botany-Zoology, Chemistry-Physics-Mathematics, Education-Psychology, Forestry, Geology-Geography and Social Science.

Officers elected for 1937 were: *President,* C. C. Todd, dean of the College of Letters and Science, State College of Washington, Pullman; *Vice-president,* J. H. Ramskill, professor of forestry, Montana State University, Missoula; *Secretary-Treasurer,* O. W. Freeman, State Normal School, Cheney, Wash.

Grants for research of funds contributed by private sources and received from the American Association for the Advancement of Science were assigned to: H. P. Klug, University of Idaho, "Photographic Records of Thermal Transitions in Substances," $50; J. H. Ramskill, University of Montana, "Development of the Hypoderm of Western Yellow Pine," $35; G. A. Matson, University of Montana, "Blood Studies of Montana Indians," $25; Dr. Van A. Odle, of Spokane, Washington, apparatus and materials for experiment on "Electrokinetic Potential of Red Blood Cells," $25.

It was announced that the Howard F. Flint Memorial Fund for research amounted to $1,031.30. The income from this will be used, beginning with next year, as a grant along forestry and biological lines.

O. W. FREEMAN,
Secretary

GRANTS IN AID OF RESEARCH BY THE GEOLOGICAL SOCIETY OF AMERICA

THE following is the list of grants in support of special research projects recently approved by the Geological Society of America:

A. A. Stoyanow, Tucson, Ariz. Grant of $1,000 covering field expenses in a revision of the Mesozoic sequence at Bisbee, Ariz.

A. O. Woodford and Edward Taylor, Claremont, Calif. Grant of $780 to cover living and traveling expenses in study of longitudinal profiles of streams, to be conducted in Europe during April and May, 1937.

Horace G. Richards, Trenton. Grant of $550 covering traveling and field expenses in study of the Pleistocene deposits and faunas of the Gulf Coastal Plain.

U. S. Grant, Los Angeles. Grant of $300 to be applied against field expenses and costs of preparing manuscript covering study of changes of the California coast.

F. H. Norton, Cambridge. Grant of $1,500 covering assistance and materials in study of hydrothermal action in minerals, particularly those that change into the clay minerals.

W. Armstrong Price, Corpus Christi, Texas. Grant of $1,200 covering traveling and field expenses of a reconnaissance of Pleistocene depositional plains of the northwestern Gulf Coastal Plain.

Charles T. Berry, Baltimore. Grant of $100 covering completion of illustrations for paper on "Ophiuran Remains from Upper Senonian of South Limburg, Netherlands."

Alfred C. Lane, Cambridge. Grant of $3,000 covering chemical analyses for studies directed to the determination of ages by the helium method.

W. E. Ford, New Haven, and Charles Palache, Cambridge. Grant of $24,000 covering assistance for four years to complete the seventh edition of James D. Dana's "System of Mineralogy."

Robert T. Hill, Dallas, Texas. Grant of $1,200 to cover expenses connected with history of geological investigation in the Southwest.

Committee headed by T. S. Lovering. Grant of $3,000 covering assistance and supplies in studies of the physical-chemical relation prevailing in a system consisting of a simple silicate and two volatiles at different temperatures and pressures.

John T. Lonsdale, Ames, Iowa. Grant of $850 covering field and office expenses connected with study of the petrography and petrology of the igneous rocks of the Terlingua quadrangle, Brewster and Presidio Counties, Texas.

AWARDS OF THE JAMES F. LINCOLN ARC WELDING FOUNDATION

THE James F. Lincoln Arc Welding Foundation, which was recently established by the Lincoln Electric Company, Cleveland, and named by the trustees in honor of its president, is dedicated to providing the public and modern industry with accurate knowledge and information on matters affecting the application of electric arc welding to machinery and equipment. One of its primary functions is the stimulation of original design, to utilize this process in modern-day fabrication.

To further this object it is planned to distribute the sum of $200,000 in 446 separate prizes for papers dealing with the subject as a primary process of manufacture, fabrication or construction in eleven major divisions of industry. The principal prize winner will receive not less than $13,700. Other prizes range from $7,500 to $100, the latter sum to be awarded to each of 178 contestants who receive no other prize, but whose papers are adjudged worthy of honorable mention.

In order to assure equal competitive opportunity, similar prizes are offered in the eleven major divisions of industry covered by the contest, which are further subdivided to insure diversification of awards. An entrant is required to select in advance the particular sub-classification to which his paper will relate and must actually have participated in the work upon which the subject-matter of it is based. The classification follows:

Automotive—engines, bodies, frames and trailers, $14,200; *aircraft*—engines and fuselage, $10,500; *the railroad industry*—locomotives, freight cars, passenger cars and locomotive and car parts, $14,200; *watercraft*—commercial and pleasure, $10,500; *structural*—buildings, bridges, houses and miscellaneous, $14,200; *furniture and fixtures*—house and office, $10,500; *commercial welding*—job shops and garages, $10,500; *containers*—contents stationary and contents moving, $10,500; *welderies*—commercial and departments of plants, $10,500; *functional machinery*—metal cutting, metal forming, electrical, prime movers, conveying, pumps and compressors, business, jigs and fixtures, parts and "not otherwise

classified,'' $25,300; *industrial machinery*—process, construction, petroleum, steel-making, farming, household, food-making, textile and clothing, printing and ''not otherwise classified,'' $25,300.

Each entrant in a sub-classification will compete for five initial prizes of $700, $500, $300, $200 and $150 to be awarded within the sub-classification. From the winners of these prizes will be chosen four papers in each major industry to receive additional prizes of $3,000, $2,000, $1,000 and $800.

RECENT DEATHS AND MEMORIALS

DR. EDWARD CURTIS FRANKLIN, emeritus professor of organic chemistry at Stanford University, died on February 4 at the age of seventy-four years.

DR. DUNCAN STAR JOHNSON, since 1906 professor of botany at the Johns Hopkins University, died on February 16 at the age of sixty-nine years.

DR. FRANK SMITHIES, professor of medicine at the Medical School of the University of Illinois, Chicago, died on February 9 at the age of fifty-six years.

Nature records the following deaths: Sir John A. F. Aspinall, past-president of the Institutions of Mechanical and Civil Engineers and also of the Institution of Civil Engineers of Ireland, on January 19, aged eighty-five years; and of David Ellis, professor of bacteriology and superintendent of the Schools of Pharmacy and Bakery in the Royal Technical College, Glasgow, on January 16, aged sixty-two years.

A CORRESPONDENT of the *Journal* of the American Medical Association reports that a bust of the late Professor Babes, founder of the first Pasteur Institute in Bucharest, was unveiled in Bucharest on October 27. The bust is placed in the square, opposite the Bucharest Bacteriologic Institute. Memorial addresses were made by Professors Bacaloglu, Ciuca, Manicatide, Marinescu and Proca. At the same time the remains of Professor Babes were interred in the crypt situated in the garden of the institute. He died ten years ago and was buried in the Bucharest Greek Catholic cemetery.

SCIENTIFIC NOTES AND NEWS

THE Cardinal Newman Award for 1936 will be presented at the University of Illinois on February 21 to Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research, New York City, for his contributions to medical science. The award is conferred annually upon the individual "who has made an outstanding contribution to the enrichment of human life in the fields of statesmanship, education, art, science or humanitarianism."

DR. RICHARD EDWIN SHOPE, of the department of animal and plant pathology of the Rockefeller Institute for Medical Research, Princeton, has been awarded the John Phillips Memorial Medal of the American College of Physicians for 1937, in recognition of his work on filterable viruses. The medal will be presented at the annual meeting of the college in April.

IN honor of the election of Dr. Frank C. Whitmore, dean of the School of Chemistry and Physics at Pennsylvania State College, as president of the American Chemical Society and as the recipient of the William H. Nichols Medal, a dinner was given by his colleagues on January 14. Dr. Grover C. Chandlee, head of the department of chemistry, presented to Dean Whitmore a congratulatory scroll signed by all staff members and graduate students in the School of Chemistry and Physics. Dr. Charles L. Parsons, secretary of the American Chemical Society, was present at the dinner and spoke briefly. Illness prevented Dr. Edward R. Weidlein, president of the society, from attending. W. R. Ham, head of the department of physics, served as toastmaster.

DR. CHARLES WALLIS EDMUNDS, professor of materia medica and therapeutics in the School of Medicine of the University of Michigan, has been appointed Henry Russell lecturer for 1937. The award was made possible by an endowment established in 1925 by the will of the late Henry Russell and is planned "to honor and reward that member of the faculty who is declared to have accomplished the work of greatest scholarly distinction during the year past." Another portion of the endowment is used to make an award to one of the younger members of the faculty who is believed to show the greatest promise in scholarly achievement. The name of the latter customarily is announced at the time of the lecture, which probably will be given in the first week of May.

DR. DAVID HILBERT, professor of mathematics at the University of Göttingen, celebrated his seventy-fifth birthday on January 23.

DR. W. G. CROCKETT, professor of pharmacy at the Medical College of Virginia, Richmond, has been elected president of the American Association of Colleges of Pharmacy.

OFFICERS of the Society of American Bacteriologists elected at the annual meeting in Indianapolis are: *President,* Dr. James M. Sherman, Cornell University, Ithaca, N. Y.; *Vice-president,* Dr. Paul F. Clark, University of Wisconsin; *Secretary-treasurer,* Dr. I.

L. Baldwin, University of Wisconsin; *Councilors-at-Large*, Dr. Paul J. Beard, Stanford University, and Dr. Malcolm H. Soule, University of Michigan. Dr. F. G. Novy, of the University of Michigan, was elected an honorary member, and Dr. A. J. Kluyver, of the Technische Hoogeschool, Delft, and Dr. Th. Thjötta, of Oslo, were elected corresponding members.

DR. CHARLES SEYMOUR, professor of history and for the last ten years provost of Yale University, has been elected president to succeed Dr. James Rowland Angell, who retires in June, having reached the age of sixty-eight years. Dr. Angell has served as president of Yale University since 1921. He was previously president of the Carnegie Corporation, chairman of the National Research Council and earlier from 1894 to 1920 professor of psychology at the University of Chicago.

CHARLES E. MCQUIGG, since 1934 director of research of the Union Carbide and Carbon Corporation, New York City, has been appointed dean of the College of Engineering of the Ohio State University. He succeeds Emeritus Dean Embury A. Hitchcock, who retired last July.

PROFESSOR A. A. ATKINSON, for a number of years head of the department of electrical engineering at Ohio University, Athens, has been appointed dean of the College of Applied Science, which includes the departments of electrical, civil and industrial engineering, industrial arts, agriculture and the School of Home Economics. Dr. W. S. Gamertsfelder, professor of philosophy, has been made dean of the College of Arts and Sciences and of the Graduate College, succeeding Dean E. W. Chubb, who retired recently.

DR. WILLIAM HENRY WESTON, JR., professor of botany and chairman of the department at Harvard University, has been appointed visiting professor of mycology at the Johns Hopkins University.

AT the University of Oxford, Cyril Norman Hinshelwood, fellow of Trinity College, has been appointed to Dr. Lee's professorship of chemistry; Dr. Hugh William Bell Cairns, of Balliol College, has been appointed Nuffield professor of surgery, and Robert Reynolds Macintosh, Nuffield professor of anesthetics.

DR. WILLIAM R. MAXON, since 1914 associate curator in immediate charge of the National Herbarium in the U. S. National Museum under the Smithsonian Institution, has been made curator.

AT the recent annual meeting of the American Society of Zoologists, three new editors of *The Journal of Morphology*, to serve three years, were elected as follows: Dr. Leigh Hoadley, Harvard University; Dr. Wm. A. Kepner, University of Virginia, and Dr. J. Percy Moore, University of Pennsylvania.

PROFESSOR ARTHUR H. COMPTON, accompanied by Professor M. S. Vallarta, of the Massachusetts Institute of Technology, returned on February 11 from Mexico, where a permanent Cosmic Ray Recording Station was established on the grounds of the Mexican National Magnetic Observatory at Teolyucan, thirty miles north of Mexico City.

DR. R. K. NABOURS, head of the department of zoology at the Kansas State College and zoologist of the Agricultural Experiment Station, has been authorized to make a trip of approximately one month beginning on February 1, to southern Mexico for the purpose of collecting specimens of grouse locusts to be used as material for his experimental work. The trip is financed by a grant-in-aid from the American Academy of Arts and Sciences of Boston.

PROFESSOR OLIVER LEE, chairman of the department of astronomy at Northwestern University, has returned to the university after six months leave of absence, which he spent at the National Observatory at Tecubaya.

DR. NIELS BOHR, director of the University Institute for Theoretical Physics at Copenhagen, has been appointed to the Hitchcock professorship at the University of California, where he will lecture during the spring semester. He plans to give a series of public lectures and will hold daily conferences and colloquia with members of the departments of physics and chemistry. The Hitchcock chair was founded in 1872 by Charles M. Hitchcock, and his gift of $10,000 to endow a single lecture each year was augmented in 1932 from the will of his daughter, Lillie Hitchcock Coit, who provided $115,000 to endow the Charles M. and Martha Hitchcock chair, in memory of her father and mother.

DR. CLAUDE S. HUDSON, professor of chemistry at the National Institute of Health at Washington, gave the second series of Forris Jewett Moore lectures at the Massachusetts Institute of Technology on February 17, 18 and 19. This series is given under the auspices of the department of chemistry for the purpose of emphasizing the cultural and humanistic relations of chemistry. The general subject of the lectures was "Isomerism in the Carbohydrate Group."

DR. CARL D. LA RUE, professor of botany at the University of Michigan, addressed the Torrey Botanical Club at a meeting held at Columbia University on February 2 on "Studies in Morphogenesis and Plant Tissue Cultures." Professor La Rue has spent the past semester in research on plant tissue culture at Harvard University.

DR. DETLEV W. BRONK, professor of biophysics at the University of Pennsylvania and director of the

Eldridge R. Johnson Foundation for Research in Medical Physics, delivered the address to the graduating class on February 13.

DR. EARLE R. HEDRICK, professor of mathematics at the University of California at Los Angeles, delivered the address on January 25 at the annual dinner of the Santa Monica Chamber of Commerce. Dr. Hedrick spoke on "Royal Roads to Learning."

HOWARD BLAKESLEE, science editor for the Associated Press and president of the National Association of Science Writers, will be the commencement speaker at the Medical College of Virginia, Richmond, next June. Austin H. Clark, of the U. S. National Museum, has been invited to be Founders' Day speaker on December 1.

ERNEST H. ANTHES, of the Scientific Instrument Division of the Bausch and Lomb Optical Company, gave the Society of Hygiene Lecture of the School of Hygiene and Public Health of the Johns Hopkins University on January 27. The lecture, entitled "Microscopy through the Centuries," was illustrated by forty-nine lantern slides of early microscopes and a working model of Leeuwenhoek's microscope.

THE National Research Council announces a limited number of post-doctorate fellowships in physics (including astronomy), chemistry and mathematics for the academic year 1937–1938. Applications, including all supplementary documents, must be submitted in triplicate to the Secretary of the Fellowship Board in Physics, Chemistry and Mathematics, National Research Council, 2101 Constitution Avenue, Washington, D. C., not later than March 1. Application forms will be furnished upon request, together with a statement of general rules and regulations. Due to prospective modification in the administration of the National Research Fellowships, republication for 1937 of the usual pamphlet concerning these fellowships has been deferred.

THE University of Oxford is inviting applications for the Nuffield professorships of clinical medicine and obstetrics and gynecology. Applications must reach the registrar of the university by April 17. The salary in each case is £2,000 per annum. The senate of the University of London invites applications for the chair of pathology tenable at the British Post-Graduate Medical School, Ducane Road, W. The salary is £2,000 per annum, and the latest date for applications is April 16.

THE rector of the University of Panama, Dr. Octavio Méndez Pereira, reports that there is an opening there for an American physicist. Further information may be secured from the Institute of International Education, New York City.

Two Loubat prizes of $1,000 and $400, for "the best work printed and published in the English language on the history, geography, archeology, ethnology, philology or numismatics of North America" will be awarded at the Columbia University Commencement of 1938. The competition is open to "all persons, whether connected with Columbia University or not, and whether citizens of the United States of America or any other country." To be considered for the 1938 awards, books must be published before January 1, 1938. Dr. Waldo G. Leland, executive director of the American Council of Learned Societies, has been appointed chairman of the jury of award. Other members are Carl L. Becker, professor of modern European history at Cornell University, and Robert H. Lowie, professor of anthropology at the University of California.

A SEISMOGRAPH designed by Dr. Hugo Benioff, of the laboratories of the Carnegie Institute of Technology and the California Institute of Technology, has been given to Williams College by Mr. and Mrs. John S. Palmer, 2d, of Providence, in memory of their son Julius, who perished about two years ago on the Ward liner *Mohawk* with two senior classmates and Professor H. F. Cleland of Williams College. The instrument will be placed in two specially constructed tiled rooms.

Industrial and Engineering Chemistry reports that a contract was signed recently for the completion of the Museum of Science and Industry founded by Julius Rosenwald in Jackson Park, Chicago. The structure and the completion of the museum involves an expenditure exceeding $3,000,000 and will require some eighteen months to build. In order to avoid the necessity of closing the museum at any time, it has been arranged to hurry the completion of the west wing, so that space may be occupied there as required.

A DENSER network of weather observation stations, better synchronized and designed primarily to provide information for more detailed and more frequent forecasts for fliers, has been established by the U. S. Weather Bureau. About one hundred new off-the-airway stations began to make six-hourly observations on January 15. Temperature, precipitation, barometric pressure, visibility, ceiling, dewpoint, etc., are to be recorded at 1:30 and 7:30, both A.M. and P.M., Eastern Standard Time. The new observations will be coded immediately and wired either to Oakland, Calif., or to Chicago, where they will be relayed, by radio or teletype, over the entire airway weather system and also to regular Weather Bureau stations. The fifty or so off-the-airway stations already in operation and about one hundred selected stations on the airways will be equipped with the same kind of

instruments. The extra observations from the new, and newly equipped, stations will amplify greatly the information on which the forecasters at the six district centers of the Weather Bureau may draw in making daily weather forecasts for the United States.

THE first number of *Population Index,* a guide to current demographic materials for students, research workers and teachers, appeared in January. The *Index* is published quarterly by the School of Public Affairs, Princeton University, and the Population Association of America. It continues the association bibliography, "Population Literature." The current number contains two new sections, Current Items and Statistics, in addition to a bibliography covering more than 400 recent books and articles.

A QUARTERLY journal devoted to the integration of the scientific disciplines and to the study of the interdependence of science and society has recently begun publication under the title *Science and Society: A Marxian Quarterly.* The editors are A. E. Blumberg, E. B. Burgum, V. J. McGill, Margaret Schlauch and B. J. Stern. The foreign editors are J. D. Bernol, University of Cambridge; Lancelot Hogben, London School of Economics and Political Science; Paul Langevin, Collège de France; H. Levy, Imperial College of Science, London; H. J. Muller, Institute of Genetics, Leningrad; Maurice Dobb, The Marshall Library, Cambridge, and Joseph Needham, of Cambridge. Editorial communications may be addressed to the managing editor, W. T. Parry, 6½ Holyoke St., Cambridge, Mass.

FIFTEEN acres of woodland have been added to the Connecticut Arboretum at Connecticut College, New London, by a gift from forty donors interested in the development of the arboretum. The deed of gift specifies that the property shall be set aside forever as a wild-life preserve. The arboretum covers seventy acres within the college property and has been set aside for the preservation and propagation of the native plant life of Connecticut. Garden clubs, horticultural societies and other organizations and individuals throughout the state are cooperating with the college in its development.

DISCUSSION

ETYMOLOGY AND PRONUNCIATION OF THE WORD "OESTRUS" AND ITS DERIVATIVES

THIS word seems to offer more difficulties as to pronunciation and spelling than any other technical word in biology. Derived originally from the Greek οἶστρος, signifying the gadfly, and taken over into Latin as *oestrus,* the word came secondarily to mean frenzy or strong desire. The Latin derivative is properly of masculine gender, following the Greek, but we are told by Tyson[1] that some grammarians gave it the neuter form *oestrum* as early as 400 A.D. In its more general senses the word became naturalized in English with the spelling *oestrum* and has been so used in prose and poetic literature by many writers (see Tyson's article and the Oxford English Dictionary).

In the original Greek and Latin the meaning of the word already included, among other forms of excitement, the recurrent sexual impulse of animals. We owe its present definite technical use, however, to the late Walter Heape,[2] whose analysis and terminology of the phenomena of the reproductive cycle form the basis of research on that subject in the present century. As pointed out by Asdell,[3] Heape was not using the well-naturalized English word *oestrum,* which in English signifies any form of recurrent excitement (*e.g.,* the poetic frenzy), but was deliberately adopting the Latin word *oestrus* for use as a specific technical term meaning in English "periodic sexual excitement of the female." Writers having the latter significance in mind should, for the sake of precision, respect the difference and use the word *oestrus.*

It is scarcely necessary to point out that the nominative form is *oestrus,* and the adjectival form *oestrous* (*cf.* fungus, fungous; mucus, mucous).

As to pronunciation, the Greek and Latin diphthong of the first syllable has become in English merely a digraph, and in England is pronounced like long *e,* as in *thief.* Wyld's Dictionary of "Received Standard English" gives this pronunciation only. The Oxford English Dictionary gives also the short *e,* as in *yet,* as an alternative pronunciation, but by the time the Shorter Oxford Dictionary reached the letter O, the compilers had discovered that the short *e* is an American usage. The word *oestrum* seems to have first appeared in the American dictionaries in the 1860 edition of Worcester and the 1864 Webster. In both cases the short pronunciation of *e* was alone given. Webster continued to give preference to this pronunciation, but since the 1909 revision cites also the long *e* as a non-preferred pronunciation. The Century Dictionary of 1911 gives the long *e* only, but on the other hand the 1913 Funk and Wagnalls gives the short *e* only.

It is evident, therefore, that the pronunciation of the non-technical word *oestrum,* and consequently of the technical term *oestrus, oestrin, oestrogenic,* etc., is

[1] Stuart L. Tyson, SCIENCE, 512: 74, 1931.
[2] Walter Heape, *Quart. Jour. Micros. Sci.,* n.s., 44: 1, 1901.
[3] Sidney A. Asdell, SCIENCE, 75: 131, 1932.

following a trend of American speech by which words beginning with the digraph *oe* tend more and more to be given the short vowel sound. The name *Oedipus* is another example. This tendency is reinforced by a corresponding tendency in spelling, to which H. L. Mencken calls attention in his book, "The American Language," namely, the conversion of decayed diphthongs into simple vowels, examples being *ecology, ecumenical, eon.* The editorial staff of the *Journal of the American Medical Association,* for example, has placed the word *oestrus* on a list of such words to be spelled without the *o,* a decision which is sure to influence the usage of American medical and biological writers. This mode of spelling has already been accepted as a variant in the 1934 revision of Webster's Dictionary, and will undoubtedly influence American pronunciation still further in the direction of the short *e.* In American speech, therefore, the short *e* should be used in pronouncing the word *oestrus* and its derivatives.

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CARBONATION VS. CARBONATIZATION

IN recent years, there has been an increasing tendency to use the term "carbonatization" for "carbonation." The writer has been unable to find the initial use of "carbonatization," but it appears in Lindgren's "Mineral Deposits" (1913, p. 70), and in later editions.

Since 1913, "carbonatization" has appeared in various geology text-books and in various publications.[1] In most of these references, the term is used as indicating carbonation (*i.e.,* the union of carbon dioxide with some base) that takes place during weathering. It is also used for the same process in connection with the deposition of ores by hot waters. This note is a protest against the use of "carbonatization" for simple "carbonation" for the following reasons:

(1) The formation of a salt by the union of carbon dioxide with bases has long been, and still is, called "carbonation" by chemists. This is also the meaning given by all standard dictionaries, such as the Oxford, Standard, Century and Webster.

(2) The suffix "ization," according to all the above-mentioned dictionaries, is used to form nouns of action from verbs ending in "ize," such verbs having been formed by adding the suffix "ize" to nouns or adjectives; the verb meaning to be or do the thing denoted by the noun or adjective (Century Dictionary). None of the authors using "carbonatization" have used the verb "carbonatize," which would seem to indicate that such a word had not been found practicable.

(3) The word "carbonatization" is a clumsy, non-euphonious term, whereas "carbonation" is much simpler.

(4) In all the above references, the authors use the term "carbonatization" along with "hydration" and "oxidation," both of which latter terms they use in the same sense as chemists do. To be consistent, those who use "carbonatization" should use "hydratization" and "oxidatization." Pronunciation of any of the three words is a laborious process. Adding letters to words already in good usage and of sound meaning is not a desirable or worthwhile practice.

(5) The use of "carbonation" is preferred by most authors of text-books on geology, as is shown by the following list:

Chamberlin and Salisbury, "Geology," Vol. 1, pp. 43, 429, 1906.

H. F. Cleland, "Geology, Physical and Historical," pp. 35–37, 1916.

Hatch and Rastall, "Text-book of Petrology, The Sedimentary Rocks," pp. 155, 206, 313, 1913.

H. W. Shimer, "An Introduction to Earth History," p. 42, 1925.

J. H. Bradley, "Earth and Its History," p. 53, 1928.

G. W. Tyrrell, "Principles of Petrology," p. 173, 1926.

W. A. Tarr, "Introductory Economic Geology," p. 62, 1930.

Emmons, Thiel, Stauffer and Allison, "Geology," pp. 39–41, 1932.

W. B. Scott, "Introduction to Geology," p. 203, 1932.

Branson and Tarr, "Introduction to Geology," p. 62, 1935.

(6) The three terms, "hydration," "oxidation" and "carbonation," as used in reference to the respective processes taking place during weathering and rock alteration, by any process, have been in use so long and indicate so simply the nature of the reaction involved with each agent that there would seem to be little justification for introducing a hybrid like "carbonatization," which adds nothing to the previous good usage.

(7) The suffix "ization" has been added to various nouns (*e.g.,* pyrite → pyritize → pyritization), in discussions of sundry types of mineral deposits, to describe processes for which no previous word had been used. Many of these words are euphonious and desirable, but "carbonatization," being neither and being wholly unnecessary in the face of the priority of "carbonation," should, in the writer's opinion, be dropped.

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[1] W. H. Twenhofel, "A Treatise on Sedimentation," p. 15, 1932; H. Ries, "Elementary Economic Geology," p. 213, 1930, and "Economic Geology," p. 491, 1930; R. H. Rastall, "Geology of the Metalliferous Deposits," pp. 138, 142, and 162, 1923; C. R. Longwell, A. M. Bateman and others, "Foundations of Geology," p. 24, 1931.

SEEDLESSNESS IN TOMATOES

IN SCIENCE for December 11, there is an interesting ews item,[1] presumably based on a recent paper[2] by r. Felix G. Gustafson, in which he describes the oduction of seedless tomatoes and other fruits as result of treating unpollinated flowers with various ganic acids. It might be of interest to some to ow that this phenomenon, in the case of tomatoes least, occurs in nature, under certain conditions.

In the Winter Garden Region of Texas, as in many her sections of the semi-arid Southwest, tomatoes ill grow all summer long under irrigation, but, with e exception of some of the small-fruited varieties ch as Red Cherry, they do not set any fruit. As a sult of a cross between Large Cherry and Bonny est some promising selections have been obtained ich have larger fruit than the small fruited parent nd which at the same time set fruits during the dverse hot dry months. The fruits of these plants ntain seeds in June, and usually also in early July, t with the higher temperatures of midsummer, they come seedless. Only once in a while will one contain seed. In November, the fruits are again seed-bearg. During this seedless period the plants bear just profusely as at other times and the fruits are of fine uality. In view of Dr. Gustafson's studies it would em that possibly the substances necessary for fruit rmation are stimulated to develop under these outhwestern conditions—perhaps by the pollination ocess. Drs. Ora Smith and H. L. Cochran have own that fertilization is often prevented under conditions of high temperatures (such as occur in Texas), ven though pollination actually takes place.[3] Practically all varieties fail to set fruits if they are not rtilized, hence the peculiar characteristic exhibited these tomato selections is an interesting one, especially so in the light of Dr. Gustafson's recent studies.

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A CASE OF INCORRECT IDENTIFICATION

GRANTIA is a sponge that occurs abundantly in Europe and figures largely in European text-books of zoology for that reason. Along the Atlantic coast of North America, and particularly at Woods Hole, Massachusetts, we have a sponge that bears a superficial resemblance to *Grantia*. Many years ago some one carelessly assumed that it was indeed that genus. A few moments are enough to show that such is not the case. *Grantia* Fleming 1828 has a distinct dermal cortex containing a special cortical skeleton of tangentially placed radiate spicules. The American so-called *Grantia* does not have such a cortex. Ours is no unknown genus, but one that has been familiar to students of sponges for over a century; it was named *Scypha* by Gray in 1821. A tentative identification as to species of the Woods Hole "Sycon" sponge may be given as *Scypha* (*Spongia*) *coronata* (Ellis and Solander 1786).

This affects a great deal of labeling in illustrations of American text-books, of museum specimens sold by biological supply houses, and especially labeling of prepared slides distributed by such companies.

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ABNORMAL FEVER CASES

CASES of patients who show abnormally high temperatures for extended periods are occasionally reported. The conclusion in such cases is usually that some artificial means is being used to warm the thermometer.

The author has found such a means in addition to the usual suggestions of heating pad and hot-water bottle that might ordinarily be suspected. If a piece of dry cloth be wrapped about the bulb of a clinical thermometer and then the breath be blown against the bulb with considerable force, it is possible to raise the temperature to 106 to 108 degrees Fahrenheit, which is usually the limit of such thermometers.

An explanation of this, suggested by Dr. F. E. Poindexter, of St. Louis University, is that the water vapor in the breath is adsorbed by the fibers of the cloth. The heat of adsorption causes the rise in temperature above ordinary body temperature.

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SCIENTIFIC BOOKS

MILLER'S COMPLETE WORKS

THANKS to the enlightened generosity of the University of Illinois the first volume of the collected works of George Abram Miller is now available to the mathematical public. In it are reprinted some 59 papers, comprising Professor Miller's contributions to the theory of groups of finite order that were published during the years 1894–99. In addition there are three essays on the early history of group theory written expressly for this volume. They will be found at pages 1, 91 and 427. This is an innovation in such a publication, but is a most happy one. These 58

[1] SCIENCE Supplement, 84: 7, 1936.
[2] F. G. Gustafson, *Proc. Nat. Acad. Sci.*, 22: 628–636.
[3] Ora Smith and H. L. Cochran, Cornell Univ. Memoir, 175, 1935.

pages represent Professor Miller's final judgment after some 40 years' continuous study of his subject. In them honor is given with meticulous care where honor is due. Here is something that can be read with interest and pleasure by every one into whose hands the volume may fall. It is hoped that more of this historical material will enrich the succeeding volumes. It is pleasing to see justice done to the Italian mathematicians, Ruffini, Abatti, Betti, Capelli, Veronese, Frattini, Giudice, Bianchi and Bagnera. No mention is made, however, of the admirable course of lectures delivered at the Ateneo of Madrid by the novelist, dramatist, statesman and mathematician, José Echegaray, and published under the title "Resolución de Ecuaciones y Teoría de Galois" in the year 1897.

The most remarkable thing known about groups of finite order was discovered by Sylow. Professor Miller brings out clearly how near Cauchy was to Sylow's Theorem, and one seems to read between the lines his regret that Cauchy did not have the good fortune to divine this great theorem for which he had a proof ready to hand. Indeed, it would have made a great difference to Jordan if he had had the use of Sylow's happy discovery when he was writing his great "Traité des Substitutions."

Since Professor Miller inserted these historical notes largely to define the place of his own work in relation to that of his predecessors and contemporaries one can criticize him only mildly for omissions. But he does not do justice to the many papers on group theory written by Jordan after 1870. For example, instead of the paragraph on page 447 devoted to the special theorem which asserts that if a primitive group of degree n contains a circular permutation of degree p (a prime) it is at least $(n-p+1)$-fold transitive, a theorem extracted from the Traité des Substitutions of 1870, it would have been better to have recalled Jordan's theorem of 1871, which may be stated as follows:

> If a primitive group G of degree n contains a transitive subgroup H of degree m, it will be at least $(n-m-2q+3)$-fold transitive, q being the greatest divisor of m such that the letters of H can be divided into systems of imprimitivity of q letters each in two or more different ways. If no divisor of m has this property (as when H is primitive or cyclic), G will be $(n-m+1)$-fold transitive.

This theorem is not exactly an epigram, and is difficult in every way, but is far deeper and vastly more important than the earlier special case that Professor Miller cites. Another piece of pioneering done by Jordan that should certainly have been mentioned is his discovery that every finite group of linear homogeneous substitutions on n variables has an invariant Abelian subgroup whose index is less than a fi[nite] limit depending on n alone.

There are other achievements of Jordan that mig[ht] well have been mentioned. As it now stands, it ma[y] seem to a reader of the volume under review th[at] Jordan is just one among many, while the fact is th[at] the amount and quality of his work in this field pla[ces] him head and shoulders above all but the astoundi[ng] genius Galois.

Professor Miller is the recognized authority o[n] groups of low order. This is the immediately usef[ul] part of the subject. The contents of this one volum[e] alone are sufficient to justify this high compliment. His first great self-imposed task was to check an[d] complete the lists of primitive groups of degree le[ss] than 18, and the intransitive and imprimitive group[s] through degree 10. Miller's lists do indeed seem t[o] be final. At the same time he was engaged on a simila[r] careful determination of the groups of low order[s] regardless of the degree. The eighteenth paper of thi[s] volume (page 131) gives a list of all the regular per[-] mutation groups whose orders are less than 48, an[d] in its 38 pages all statements made are proved. In particular he corrected the fantastic assertion of L[e] Vavasseur that there are at least 75 groups of order 32, a number that was definitely fixed in this masterly memoir at 51. Here too is found for the first time the commutator subgroup and the proof that the quotient group with respect to it is Abelian, and that no proper subgroup of the commutator subgroup has an Abelian quotient group. This was an important advance in the use of the commutator: $s^{-1}t^{-1}st$.

In looking through this volume it is interesting to note the gradual growth of the abstract group idea. One elementary theorem that is now in constant use took form as that idea became clearer. It occurs twice (without proof) in this volume, and it is instructive to compare the two versions. On page 252 we find:

> If a group contains two self-conjugate subgroups that have only the identity in common, it may be represented as an intransitive group which is not simply isomorphic to any one of its transitive constituents.

Then on page 363 there is the more definite statement, referring clearly to an abstract group:

> If a group contains two self-conjugate subgroups (differing from identity) which have only identity in common, it can always be represented as an intransitive group which involves no transitive constituent whose order is equal to the order of the group. As such transitive constituents we may use the quotient groups (represented as substitution groups) with respect to the two given self-conjugate subgroups.

This seems to be the first statement of this fundamental theorem; but why did Professor Miller no[t]

ve a proof? It is probable that he visualized the o quotient groups side by side in two columns and aw" that the resulting intransitive group would be imply isomorphic to the given abstract group, and ropositions seen in this way are sometimes awkward ings to put down in black and white.

The two papers in which the primitive groups of egree 15 and degree 16 are determined are models their kind. In the second, page 270, it is shown Miller's easy, graceful, flowing style that all the imitive groups of degree 16 (not alternating or mmetric) contain a self-conjugate subgroup in hich every permutation is of order 2. This result suggests how inaccessible are the groups of degree 32, and how pitifully few are the distinct families of primitive groups we know or can reasonably hope to know.

The volume is very handsome. Paper and typography are all that could be desired, and the editing and proofreading is as near perfection as is humanly possible. As to misprints, it ties the present record of Lehmer's list of primes, as far as the reviewer was able to discover in an extensive but not complete reading.

W. A. MANNING

STANFORD UNIVERSITY

SPECIAL ARTICLES

THE ISOLATION OF A HOMOGENEOUS HEAVY PROTEIN FROM VIRUS-INDUCED RABBIT PAPILLOMAS

Two years ago[1] a crystalline protein was obtained by chemical treatment of the juice of plants diseased with tobacco mosaic virus. Numerous chemical, biological and physical experiments[2] indicate that this protein is the agent responsible for the disease. Similar chemical procedures have not yielded pure virus proteins from plants infected with other viruses. Recently, however, the development of methods involving differential ultracentrifugation has made possible the purification of proteins associated with the activity of certain of the less stable plant viruses.[3] The effectiveness of these methods has suggested the desirability of similar studies with animal viruses. The unusual stability of the virus causing infectious papillomatosis (Shope) recommends this agent as a favorable subject for such a study.

We have isolated from the virus-induced warty masses[4] from western cottontail rabbits a high molecular weight protein with which is associated the infectiousness of the disease. The following procedure has been adopted in preparing this protein. From 5 to 10 grams of glycerolated wart tissue known to be infectious were ground with sand and extracted with 100 cc of normal saline. After preliminary clarification by low-speed centrifugation extracts were ultracentrifuged[5] in 17 cc tubes for about two hours in a maximum field of 60,000 times gravity. The pellets thus thrown down were pooled and taken up in 7 cc of 0.1 M phosphate buffer solution, cleared of aggregated colloidal matter by low-speed centrifugation and again ultracentrifuged at 60,000 g to yield a pellet of heavy matter. This process was continued 3 to 4 times, or until tests with the analytical ultracentrifuge showed that all light-weight impurities had been lost in the supernatant fluids and all fine colloidal matter had been aggregated and eliminated through the intermediate low-speed centrifugations. Sixty grams of wart tissue derived from 5 different sets of warts were treated in this fashion. In 3 instances the papillomas were the result of "natural" infections; in the other 2 the growths had been induced by experimental inoculation. These tissues had different degrees of infectivity, suspensions of the most active producing rapidly growing papillomas in domestic rabbits 7 days after inoculation of saline extracts, the poorest requiring 13 days for the production of scattered warts.

Differential ultracentrifugation in each case provided a heavy protein free from colloidal impurities and detectable amounts of light-weight contaminants. A solution containing one mg per cc of this purified substance was opalescent and gave positive color reactions with the Millon, xanthoproteic and biuret reagents. A portion of the same solution failed to yield an immediate positive Molisch test for carbohydrate, but a faint violet ring of color developed on standing. The material was found to contain about 15 per cent. nitrogen by Kjeldahl analysis. The heavy protein is completely coagulated at a temperature of 66–67° C. and leaves a supernatant that is free of protein; the activity of papilloma extracts[6] begins to diminish at 67° C. and is completely destroyed at 70° C.

In the analytical ultracentrifuge the heavy protein from each sample sedimented with the sharp boundary that characterizes a single molecular species. In every instance the sedimentation constant was the same—

[1] W. M. Stanley, SCIENCE, 81: 644, 1935.
[2] W. M. Stanley, *Amer. Jour. Bot.*, 24: No. 2, 1937.
[3] W. M. Stanley and R. W. G. Wyckoff, SCIENCE, 85: 181, 1937.
[4] We are indebted to R. E. Shope of this Institute for the material used in this investigation.
[5] R. W. G. Wyckoff and J. B. Lagsdin, *Rev. Sci. Instr.*, No. 3, 1937.
[6] R. E. Shope, *Jour. Exp. Med.*, 58: 607, 1933.

$S_{20°}$ = ca 250×10^{-13} cm. sec.$^{-1}$ dynes^{-1}. If this papilloma protein has about the same shape in solution as the tobacco mosaic virus protein molecule,[7] it will have a molecular weight somewhat in excess of 20,000,000; such a particle is about 40 millimicrons in diameter.

Practically the same yield (0.22 to 0.26 mgr per gram) of heavy protein was derived from all materials except one, which was notably richer (0.81 mgr per gram). In 3 experiments the effect of each centrifugation upon the infectious principle was determined. To do this, serial dilutions of the original saline extracts, supernatant fluids and solutions of the sedimented pellets were titrated in domestic rabbits.[8] The minimum amount of purified protein needed to produce warts visible 17 days after inoculation was between 10^{-7} and 10^{-8} grams, whereas between 10^{-5} and 10^{-6} grams of total protein in the saline extracts was required for comparable infection. The heavy protein was several thousand times as infectious as the wart tissue from which it was derived. These results show that there was no appreciable loss of viral activity at any point in the preparation, that it followed the heavy protein at every step and was concentrated with it.

There is other evidence that this protein is intimately associated with the viral activity. Active extracts of cottontail rabbit papillomas produce exuberant growths in domestic rabbits. These warty masses, however, usually yield no active virus.[9] We have subjected the extract from ten grams of domestic rabbit wart tissue, found in repeated tests by Shope to be non-infectious, to the ultracentrifugal concentration and analysis described above. No heavy protein was found.

We wish to express our indebtedness to W. M. Stanley for the invaluable advice he has given.

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ACETYLATION OF PARA-AMINOBENZENESULFONAMIDE IN THE ANIMAL ORGANISM[1]

PARA-AMINOBENZENESULFONAMIDE has been shown to have a remarkable protective and curative action in β-hemolytic streptococcic infections in animals,[2] and is being used in the treatment of such infections in human beings. We became interested in studying the pharmacology of para-aminobenzenesulfonamide and have accumulated considerable data on its absorption and excretion. Quantitative determination can be made by diazotizing, coupling in acid solution with dimethyl-α-naphthylamine and comparing the color obtained with that obtained from standard solutions. With this method, we have shown that in the dog the substance appears to be excreted mainly or entirely in unchanged form, while in the rabbit and human it is excreted partly as a conjugated compound from which the original substance can be obtained by hydrolysis with dilute acid.[6] We present here data on the isolation and identification of a conjugated compound obtained from the urine of rabbits and humans after the administration of para-aminobenzenesulfonamide by mouth. We have also isolated the unchanged sulfonamide from the urine of dogs and humans.

A sample of urine obtained from a dog, which had received 1.0 gm per kgm of para-aminobenzenesulfonamide, deposited crystals on cooling in the ice box. These on recrystallization from dilute alcohol melted at 167–8°, a mixture with pure para-aminobenzenesulfonamide (M.P. 166–7°) melted at 167–8°. The crystals from the urine when analyzed by the colorimetric method checked a standard solution of the pure substance within 2 per cent.

A rabbit weighing 3.5 kgm received 3.5 gms sulfonamide by mouth. Urine collected for the next 24 hours deposited crystals on standing over night. These were filtered off, recrystallized several times from water and dilute alcohol and finally from water. The final product consisted of beautiful needles melting sharply at 219°. Gelmo[7] gives the melting point of para-acetylbenzenesulfonamide as 219°.

Analysis:

Found N by micro-method 12.72 per cent.; 12.82 per cent.
Theoretical N for $CH_3CONHC_6H_4SO_2NH_2$ = 13.05 per cent.

Acetic acid was identified after hydrolysis as silver acetate, which was analyzed for silver with the following results.

[1] This investigation has been aided by a grant from the Josiah Macy, Jr., Foundation.

[2] J. Tréfouël, Mme. J. Tréfouël, F. Nitti and D. Bovet, *Compt. rend. Soc. de biol.*, 120: 756, 1935.

[3] G. A. H. Buttle, W. H. Gray and D. Stephenson, *Lancet*, 230: 1286, June 6, 1936.

[4] P. H. Long and E. Bliss, *Jour. Am. Med. Assoc.*, 34, January 2, 1937.

[5] L. Colebrook, G. A. H. Buttle and R. A. Q. O'Meara, *The Lancet*, 231: 1323, December 5, 1936.

[6] E. K. Marshall, Jr., K. Emerson, Jr., and W. C. Cutting. In press. *Jour. Am. Med. Assoc.*, 1937.

[7] P. Gelmo, *Jour. für praktische Chemie*, 77: 369, 1

[7] I. Eriksson-Quensel and T. Svedberg, *Jour. Am. Chem. Soc.*, 58: 1863, 1936; R. W. G. Wyckoff, J. Biscoe and W. M. Stanley, *Jour. Biol. Chem.*, 117: 57, 1937.

[8] J. G. Kidd, J. W. Beard and P. Rous, *Jour. Exp. Med.*, 64: 63, 1936.

[9] R. E. Shope, *Proc. Soc. Exp. Biol. and Med.*, 32: 830, 1935.

Found Ag = 63.4 per cent.
Theoretical for $C_2H_4O_2$ Ag = 64.04 per cent.

A solution of these crystals gave no color after diazotization on the addition of dimethyl-α-naphthylamine (no free NH_2-group on the benzene ring). After hydrolysis with dilute hydrochloric acid, the substance gave (by colorimetric method) 80.0 per cent. and 78.8 per cent. of para-aminobenzenesulfonamide. Theoretical for

$CH_3CONHC_6H_4SO_2NH_2$ = 80.3 per cent.

The above data prove the conjugated compound obtained from rabbit's urine to be para-acetylaminobenzenesulfonamide.

This acetyl derivative has been obtained in several other experiments from the urine of rabbits given large doses of the sulfonamide. The following experiment gives a rough idea of the recovery.

A rabbit weighing 1.7 kgm received by mouth 1.7 gms of para-aminobenzenesulfonamide. Ninety cc of urine were secreted in the following 24 hours. This urine was heated just to boiling to dissolve a precipitate, and, while hot, 5 cc were taken and diluted for analysis. From this analysis the remaining 85 cc were calculated to contain 235 mgms of free para-aminobenzenesulfonamide and 1,010 mgms of the conjugated form (calculated as the acetyl compound). The 85 cc of urine were allowed to remain in the ice box for 2 days, the deposited crystals filtered off and dried. Six hundred mgms were obtained. On analysis, these crystals were found to contain 2 per cent. of free sulfonamide and 95 per cent. of the conjugated compound (calculated as the acetyl derivative). After three recrystallizations from water, the compound melted at 218°, and when mixed with para-acetylaminobenzenesulfonamide (the sample which had been identified) melted at 218°. The second 24-hour urine sample contained a considerable amount of the conjugated compound (by colorimetric analysis).

From the urine of a patient being treated with the sulfonamide para-acetylaminobenzenesulfonamide has been isolated and identified.

A 24-hour specimen of urine measured 980 cc. Analysis of a small sample showed it to contain 1.20 gm of free and 1.25 gm of conjugated compound (calculated as acetyl derivative). The urine was treated with 5 gms of charcoal (Norit), shaken and allowed to stand in the ice box for 8 days (a shorter time is sufficient). The charcoal was removed by filtration, and the filtrate analyzed. The filtrate contained 1.03 gm of the free and 0.25 gm of the conjugated compound. The charcoal was treated with 75 cc of 95 per cent. alcohol, heated for a few minutes on a water bath and allowed to stand over night. The charcoal was removed by filtration, the filtrate evaporated to about 15 cc, several volumes of hot water added and the solution placed in the ice box for 4 hours. The crystals obtained by filtration weighed 0.34 gm (dried at 100°). Colorimetric assay showed only a small trace of free sulfonamide, but after hydrolysis the sulfonamide content was increased to 77 per cent. The substance was nearly pure para-acetylaminobenzenesulfonamide. After solution of the 0.34 gm in hot alcohol, hot water was added and the solution was placed in the ice box over night. After recrystallization from water and drying at 90°, the needles melted at 219°, and a mixture of them with the acetyl compound from rabbit's urine melted at 219°. On the colorimetric assay after hydrolysis, the purified compound gave 80.6 per cent. para-aminobenzenesulfonamide, the theoretical being 80.3.

From the urine of another individual receiving the sulfonamide, both the unchanged sulfonamide and the acetyl derivatives were isolated in small amounts by evaporation and fractional crystallization and identified by mixed melting points. This method is laborious and was done before the selective adsorption of the acetyl derivative by charcoal was discovered.

We can conclude that in the rabbit and man the conjugated compound found in the urine after administration of para-aminobenzenesulfonamide by mouth is mainly, if not entirely, the acetylated derivative. It is interesting to note that this is another example of an aromatic compound containing an amino group attached to the benzene ring which the rabbit and man can acetylate but the dog can not.[8]

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DIFFRACTION OF X-RAYS AT VERY SMALL ANGLES BY CELLULOSES AND RAYONS

FROM our laboratory have been reported already the measurements of very large spacings for a number of natural materials. These include 171 A.U. in living nerve,[1] 440 A.U. in collagen, 48 A.U. for radially oriented natural wax in intestinal wall collagen,[2] 81 A.U. in keratin, 58 A.U. in gel rubber and 75 A.U. in chitosan.[3]

By extending the experimental technique to its fullest possibilities, many attempts have been made to resolve interferences at very small angles corresponding to very large spacings in cellulose and its deriva-

[8] J. B. Muenzen, L. R. Cercedo and C. P. Sherwin, *Jour. Biol. Chem.*, 67: 469, 1926.
[1] *Radiology*, 25: 131, 1935.
[2] *Radiology*, 27: 339, 1936.
[3] *Jour. Am. Chem. Soc.*, 57: 1509, 1935; *Jour. Phys. Chem.*, 40: 863, 1935.

tives. In most of these cases there is a definite but somewhat diffuse scattering at very small angles. Equatorial maxima run out from this halo like small arrowheads, but in spite of ingenuity in obtaining the very sharpest possible patterns, it has been impossible to resolve these equatorial streaks into a series of individual spots. There are, however, some very interesting characteristics of this phenomenon which seem worth recording.

Fig. 1*a* is a diagrammatic representation of the

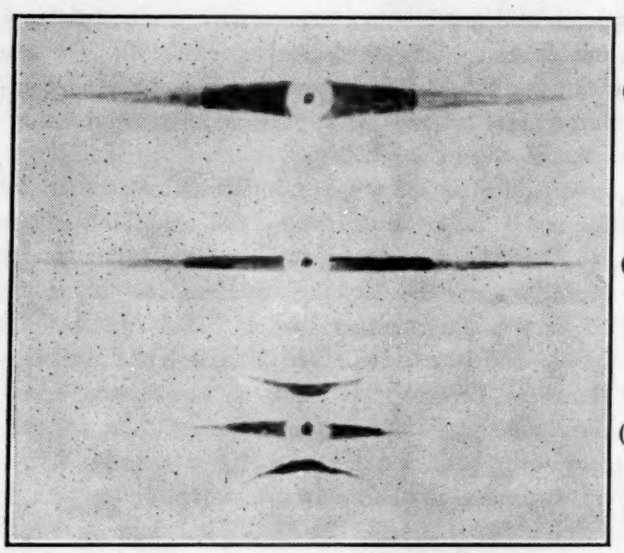

FIG. 1. Diagrams of diffraction effects at very small angles of fiber pattern. (*a*) Native ramie. (*b*) Mercerized ramie dried under tension. (*c*) Regenerated cellulose rayons (nitro, cuprammonium, viscose).

innermost part of a diffraction pattern for native ramie. A continuous streak runs along the equator from the central spot of the pattern, which is widest at the smallest angles and tapers gradually to a nearly constant width of blackening on the film. The greatest intensity seems to be reached at a spacing of about 40 A.U., followed by a rapidly diminishing intensity down to about 20 A.U. The obvious explanation of this pattern seems to be that a whole range of lateral spacings between macromolecules, crystallites or micelles occurs. The greater this spacing is, that is, the smaller the angle, the less perfect is the longitudinal arrangement along the length of the chains in the crystallites so that the resulting diffraction effect is increasingly more diffuse or wider.

In Fig. 1*b* is represented the innermost part of the pattern of mercerized cellulose dried under tension so that the greatest preferred orientation can be gained. The same equatorial streak can be observed as with the original native ramie, but now it is very sharp and uniform in width until it merges with the trace of the undiffracted beam. The marked effect, therefore, of pulling the chains more nearly parallel to each other is directly indicated.

Fig. 1*c* represents an entirely new finding for rayon. With the most careful technique involving very small pinholes, careful blocking of the primary beam, vacuum camera and similar details, we find for all regenerated cellulose rayons, including nitro, cuprammonium and viscose, the production of a very sharp equatorial streak and very definitely a first layer line on either side from which can be measured a fiber identity period of 154 A.U. Acetate rayons do not give this pattern but only a fairly diffuse general scattering around the central spot. The progression in regularity of structure from native ramie to mercerized ramie when dried under tension and then to commercial rayons seems to be clearly indicated by these curious unresolved diffraction maxima at very small angles.

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SECONDARY INCREASE OF LENGTH OF STRETCHED CHILLED RUBBER[1]

DURING some work on "frozen" crude rubber, we have noted that stretched samples behave in a curious way that may have significance in attempts at explaining the rubbery state.

It is well known that crude rubber becomes hard and opaque at low temperatures, and is then said to be "frozen" or "boardy." It exhibits most of the phenomena associated with true crystallization; for instance, a development of well-marked, strongly birefringent granules, a decrease in volume during freezing and an incipient formation of crystal nuclei at a low temperature before contraction in volume begins.

In the current investigation we have noted the following strange behavior of crystallizing samples. When a piece of crude rubber, for example, a strip about 5 mm wide and 2 mm thick, is stretched moderately, cooled to $-25°$ C. and maintained at that temperature, it first becomes hard and then during a few hours the length of the stretched piece increases about 4 per cent. A strip of rubber, stretched and nailed to a board, rises to form an arc between the points of attachment. This secondary elongation is roughly independent of the amount of stretch if the increase in length has been between 20 and 300 per cent. We have observed it with smoked sheet, pale crepe, milled pale crepe and with smoked sheet that has been swelled slightly by benzene to remove strains, and thoroughly dried. It is absent or feeble with vulcanized rubber.

[1] Publication approved by the director of the National Bureau of Standards of the U. S. Department of Commerce.

or with rubber that has been stretched to the degree at which it displays marked resistance to further elongation. The elongation does not occur with unstretched rubber. The effect is not simply a component of the volume changes which occur on stretching or freezing, but is opposite in direction and has at least four times the magnitude which such volume changes would produce. Measurements have not yet been made of the change of volume accompanying the elongation. By analogy with the contraction of stretched rubber on heating, it seems probable that this phenomenon is related to the Gough-Joule effect, and that the increase in length is accompanied by a lateral contraction of such magnitude that the volume decreases.

Available evidence indicates that rubber hydrocarbon consists of very long molecules. When rubber is stretched, these molecules tend to be oriented parallel to the direction of elongation, so that, when freezing begins, a crystalline axis has already been established. The crystals are correspondingly oriented. During freezing a time comes when enough molecules have fallen into crystalline spacing to harden the sample and relieve the stresses that produced stretching. As more molecules move into the crystalline arrangement, the spacings at right angles to the stretch become less, the long directions of the molecules become more strictly parallel to the axis of stretch, and the sample is elongated. This explanation is supported by unpublished evidence regarding crystal growth at approximately – 25° C.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

POTENTIAL MEASUREMENTS IN OXIDO-REDUCTION MIXTURES[1]

IN the series "Studies on Oxidation-Reduction,"[2] Clark has described the apparatus used for potential measurements of oxido-reduction dyes in various ratios of oxidant and reductant. The mounting of the potentiometer and the gas purification being left out of consideration, the principle of this apparatus is briefly the following.

Reductant is sucked out of the reduction vessel into a reservoir. Here the hydrogen gas still present is removed from the reductant by passing nitrogen through it. Now a burette may be filled from the reservoir, so that measured quantities of reductant may be introduced into the electrode vessel. We then found that this apparatus might quite well be simplified, while retaining the principle according to Clark, by leaving out the reservoir and substituting the burette for it. At the same time the number of taps is in this way reduced from 6 to 3, as is apparent from the figure (Fig. 1). During the numerous determinations of oxido-reduction curves executed with this apparatus, it has continually proved to answer the purpose easily. This may justify this short communication.

The apparatus is used in the following manner: Via A, three-forked tap X (T shape) and B the electrode vessel C may be made free from oxygen by passing nitrogen through it. *Via* G and three-forked tap Y the nitrogen may be led through burette D and then either to the electrode vessel (*via* three-forked tap Z with double boring) or to the reduction vessel M, first

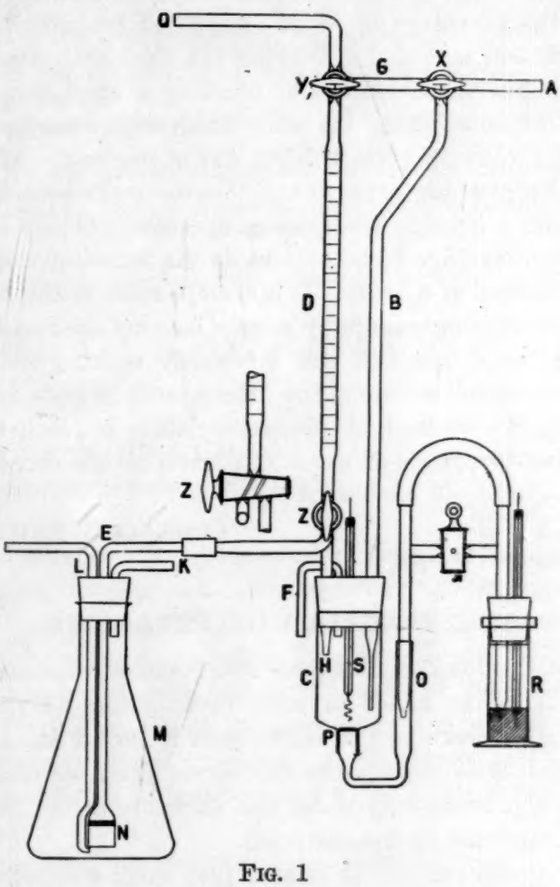

FIG. 1

driving away the oxygen and after reduction the hydrogen. The stream of hydrogen passes to M *via* L. By connecting Q with a water spout air pump, the reductant may directly be sucked into burette D, after being freed from hydrogen in the reduction vessel. This takes place under overpressure of nitrogen in M *via* a tube of communication with L which has not been drawn in the figure. After the burette has been filled,

[1] From the Histological Laboratory of the University of Amsterdam. Director, Professor Dr. G. C. Heringa.
[2] No. 3, pp. 31–36, U. S. Government Printing Office, Washington, 1928.

the stream of nitrogen is again led *via* A to D, so that the vacuum above the reductant is filled with nitrogen. By means of tap Z an accurately measured quantity of reductant may then be added to the oxidant in the electrode vessel. As a rule 9 cc. of the oxidant was brought into the electrode vessel and to this was added 1, 1.25, 1.60, 2.15, 3, 4.5, 7.5, 15 and 45 cc., respectively, of the reductant. Thus the ratios oxidant: reductant were gone through from 9:1 to 1:9. Likewise for the measurement of oxido-reduction curves with solutions of reducing salts this apparatus is very useful.

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MUSEUM LABELS

REGARDING the suggestion of Professor Tolmachoff in SCIENCE of November 20, concerning an enamel patch and lettering system for museum labels, perhaps a simplified variation may also be of interest. Instead of ordinary gloss enamel, use is made of one of the modern lacquers such as white Duco. This not only has the advantage of rapid drying but has a surface which will take India drawing ink used with a steel pen. The inconvenience of cleaning a brush can be avoided by applying the white finish with a toothpick of the ordinary type which is flat at one end. After a little practice, a patch can thus be made as neatly as with a brush. The average operator will find it a great advantage to be able to do the lettering with a pen instead of a brush. It is even possible to dispense with a stirring paddle by merely keeping the can less than two thirds full and vigorously shaking before each occasion of use. For infrequent but busy occasions, this method of preparing labels is ideal, and during two years of use it has given all the satisfaction that could be desired.

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THE FLAGELLA OF PERANEMA

DUE to the fact that there still remains considerable doubt in the minds of some investigators (Hyman, 1936)[1] concerning the existence of a second flagellum in *Peranema trichophorum*, it seems advisable to suggest a procedure by which this structure in the living organism can be demonstrated.

Korschikow (1924)[2] stated that weak solutions of gentian violet stain would cause the second flagellum, which is adherent to the periplast, to be loosened and to extend away from the cell because of the increase in metabolic movements of the organism. I have used a 0.02 per cent. concentration by weight of this stain and have obtained excellent results by the addition of equal parts of the stain and culture medium on a slide. A cover slip was used and the resultant solution examined at once with a 4 mm objective. The peranemas which come into contact with the stain become very metabolic and, in many cases, after a short interval the second flagellum is visible projecting from the anterior end of the animal.

Students in protozoology at Ohio State University have used this procedure repeatedly in classroom work and the stain has proved to be effective in approximately half the cases.

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[1] Libbie H. Hyman, *Quart. Jour. of Micros. Sci.*, 79: 43–56.

[2] A. A. Korschikow, *Arch. russ. Protist.*, 3: 148–205.

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